10/533975

5

A DETECTION METHOD OF LIFT GUIDE RAIL PERPENDICULARITY AND A DETECTOR FOR IMPLEMENTING THIS METHOD

10 **Field of the Invention**

The invention relates to a detection method and a detector for implementing the method. Particularly, it relates to a detection method for measuring perpendicularity of the guide rail of a lift and an apparatus for practicing the method.

15

Background of the Invention

The installation quality of the guide rail of a lift, especially the error on perpendicularity, is an important factor affecting the proper operation of the lift.

20 Detection of lift guide rail perpendicularity is a key step to ensure the installation quality of the lift. According to stipulations of GBJ310-88 *Detection and Evaluation Standards for Engineering Quality of Lift Installation*, the error allowance requirement for lift guide rail perpendicularity is 0.7 mm of per 5 m, using the "plumb line and dipstick metering" method. According to *Lift Supervision and Detection Regulations*

25 issued by General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China, 2002-1-9, the maximum error allowance per 5 m of working surface of each guide rail is as follows: 1.2 mm for car guide rails and T counterweight guide rails with safety gears; 2 mm for T counterweight guide rails without safety gears, using laser vertical collimator or magnetic plumb of 5 m in

30 length, measuring along the side and top working surfaces of the guide rail, and detecting sectionally and continuously per 5 m along the vertical line and no less than three sections for each side. The "plumb line and dipstick metering" method has been

used to detect guide rail perpendicularity for several decades. Its advantages are using simple measuring and metering tools and obtaining results directly from visual measurements but its shortcomings are inconsistent measuring accuracy among different operators with varying operating skill and visual reading errors, the difficulty

5   for achieving automatic data collection, and low work efficiency.

In recent years, the method with laser vertical collimator is introduced for detecting lift guide rail perpendicularity. For example, the method with JZC-A laser vertical collimator of automatic alignment to detect lift guide rail perpendicularity has been

10   applied for patent by LaTe Laser Technology Development Limited Company of Dalian Development Zone and has been used widely. The method has improved the measuring accuracy and work efficiency over the traditional method of "plumb line and dipstick metering." However, while the pull wire is replaced by the laser beam in the newer method, both methods are basically identical in measuring theory and process.

15   For the newer method, each detection position is still manually measured seriatim and data are still read and collected manually.

Summary of the Invention

20   An object of the present invention is to overcome the shortcomings of the existing technologies and to provide a detection method in which the detected data are picked up and outputted by sensors and collected, analyzed and outputted automatically by a microprocessor as well as a detector for practicing this method.

25   A method for detecting lift guide rail perpendicularity of the present invention comprises the following steps:
       1.   selecting several monitoring points on the side or top working surface of the lift guide rail under testing;
       2.   sequentially measuring position coordinates of each monitoring point in the

30   longitudinal direction of the guide rail and the distance between two adjacent monitoring points;

3.   sequentially measuring the included angle between the connecting line of two adjacent monitoring points and the plumb line; and

4.   calculating, analyzing and transforming the measured data such as position coordinates of each monitoring point in the longitudinal direction of the guide rail, the

5   included angle between the connecting line of two adjacent monitoring points and the plumb line and the distance between two adjacent monitoring points, etc, obtaining error data on guide rail perpendicularity, plotting curve graphic chart of perpendicularity.

10   In order to practice the above detection method, the present invention further provides a detector for detecting lift guide rail perpendicularity, which is detailed in the following technical description.

The detector comprises an instrument frame, at least two detector heads which can

15   contact with working surface of the guide rail, a displacement sensor used to measure the displacement distance of the detector heads along the guide rail, an inclination sensor used to measure the included angle between the connecting line of the two detector heads and the plumb line, a microprocessor used to process the measured data and a power supply unit installed on the instrument frame; output terminals of the

20   displacement and inclination sensors connect with input terminals of the microprocessor.

The detector heads that can contact with the working surface of the guide rail are of a roller type or slide block type, on which a pressing unit is installed.

25

The pressing unit is a spring type or magnetic force type.

The displacement sensor may be a rotary encoder that is connected with rollers of detector heads by a flexible coupling.

30

The displacement sensor may be a photoelectric sensor which will not contact with the working surface of the guide rail and keep a gap of at least 1 mm from the working surface of the guide rail.

5   The advantages of the present invention are: the detected data are picked up by the sensors and directly inputted into the microprocessor, and analyzed and outputted by the microprocessor, so that automation and intellectualization of perpendicularity detection for lift guide rails are achieved.

10   **Brief Description of the Drawings**

FIG.1 is a diagram showing the structure of a detector of the present invention;

FIG.2 is a sectional view of the A-A section of the detector in FIG.1;

15

FIG.3 is a diagram showing the structure of another detector of the present invention;

Embodiments of the Invention

20   The following is further detailed description of the present invention in conjunction with the embodiments and the drawings.

A method for detecting lift guide rail perpendicularity of the present invention comprises the following steps: selecting several monitoring points on the working surface of the lift to be detected; sequentially measuring position coordinates of each
25   monitoring point in the longitudinal direction of the guide rail and the distance between two adjacent monitoring points; sequentially measuring the included angle between the connecting line of two adjacent monitoring points and the plumb line; obtaining error data of the lift guide rail perpendicularity according to the measured data;
30   plotting curve graphic chart of perpendicularity and so on; the structures of two specific embodiments of the detector for practicing the detection method of lift guide

rail perpendicularity of the present invention are shown in FIG.1 and FIG. 3 respectively; in one structure there are installed with two detector heads 1 and 8, an displacement sensor 4, an inclination sensor 5, a microprocessor 6 and a power supply unit 7 installed on instrument frame 12 (shown in FIG.1); in the other structure

5   (shown in FIG.3), besides the elements of the structure shown in FIG.1, there are two additional detector heads 14 and 15. Detector heads1, 8, 14 and 15 of the detector may be a roller type or slide block type; the distance between two detector heads can vary from 300 mm to 2000 mm according to measuring requirements; the output terminals of displacement sensor 4 and inclination sensor 5 connect with the input

10   terminals of microprocessor 6.

Embodiment 1:

The detector of this embodiment is mainly used to detect perpendicularity of the side working surface of a lift guide rail. FIG.1 illustrates the structure of the detector and

15   FIG. 2 shows that the detector heads are contacted tightly with the side working surface by the action of the contact roller at the A-A section.

In this embodiment, detector heads 1 and 8, installed rigidly on the upper and lower

20   parts of instrument frame 12 respectively, have a roller type structure. For the convenience of measuring and calculation, the predetermined distance between detector head 1 and detector head 8 is 537 mm. In using this detector, detector heads 1and 8 are contacted tightly with one side working surface of the guide rail and pressing roller10 contacts tightly with the opposite side working surface of the guide

25   rail, then tightening spring 13 applies a pressure of 20-30N on pressing roller 10 by pressed arm 11 to ensure detector heads 1 and 8 to contact with the side working surface of the guide rail at all times. Pressed arm 11 is installed on instrument frame by pin 9.

30   In this embodiment, displacement sensor 4, with the structure of a rotary encoder connected with the roller of detector head 1 by flexible coupling 2, is used to measure

the displacement distance of detector head 1 along the guide rail. When detector
head 1 moves along the guide rail, the relative moving direction and distance of the
detector to the guide rail are determined by the rolling direction and rotary values of
the roller of detector head 1 along the surface of the guide rail, and the rotary values

5   are outputted by way of electric pulse code.

In this embodiment, inclination sensor 5, installed rigidly on instrument frame 12 with
the same installation method by which detector head 1and 8 is installed, measures
the included angle between the connecting line of detector heads 1and 8 and the

10   plumb line. In order to ensure the detecting accuracy, A U.S. made TAB-U inclination
sensor of with a resolution of 0.001° (which equals to a perpendicularity resolution of
0.01mm) is used. In measuring the guide rail perpendicularity, inclination sensor 5 can
measure values of the included angle between the plumb line and the line connecting
the two monitoring points within each measuring section. Because the distance

15   between detector head 1 and detector 8 is 537 mm, when the detected value of the
included angle deviates each 0.1 ° from the reference, it represents a perpendicularity
error of 1 mm.

During the operation, the detector can slide on the guide rail under testing. As the

20   detector is sliding on the guide rail, the measuring data are picked up timely and
outputted into microprocessor 6 by displacement sensor 4 and inclination sensor 5,
then analyzed and calculated by microprocessor 6, and finally outputted as a curve
graphic chart of perpendicularity and the perpendicularity error value at each
monitoring point of the guide rail.

25

Using the detector of this embodiment to practice the detection method of the present
invention comprises the following steps:

1.   Detector heads 1and 8 of the detector simultaneously contact with the side

30   working surface under testing, position 1 of detector head 1 is referenced as the first
monitoring point and position 2 of detector head 8 as the second monitoring point; the

known distance between two monitoring points (i.e., the distance between two detector heads) is 573 mm, and the included angle between the connecting line of two monitoring points and the plumb line has been measured by inclination sensor 5; then relative perpendicularity error value of the second monitoring point to the first

5   monitoring point equals to 573 × tg α, and the calculation is performed by microprocessor 6.

2.   The detector slides along the guide rail under testing, and the values of sliding distance are measured by displacement sensor 4; when the sliding distance is equal

10   to the distance between two detector heads, detector heads 1 and 8 are located in the second and third monitoring points respectively; the included angle between the connecting line of two monitoring points and the plumb line in this measuring section is measured by inclination sensor 5; according to the same theory, the microprocessor carries out the calculation of relative perpendicularity error value of

15   the third monitoring point to the second monitoring point.

3.   The detector slides continuously along the guide rail under testing, and the values of the sliding distance are measured by displacement sensor 4; when the sliding distance is equal to the distance between two detector heads, detector heads

20   1 and 8 are located in the third and fourth monitoring points respectively; the included angle between the connecting line of two monitoring points and the plumb line in this measuring section is measured by inclination sensor 5; according to the same theory, the microprocessor carries out the calculation of relative perpendicularity error value of the fourth monitoring point to the third monitoring point.

25

4.   Repeat the above process for each measuring section until the detector reaches the end of the guide rail, whereby obtaining a series of the relative perpendicularity error value between two monitoring points within each measuring section.

30

5.   Build a coordinate system where the Y axis represents the length along the guide rail and the X axis represents the value of perpendicularity error; the distance from the beginning to the position of each monitoring point on the guide rail is taken as the y value and the relative perpendicularity error value between two monitoring

5   points in each measuring section is taken as the x value to plot a curve diagram chart of perpendicularity; the perpendicularity error value at each monitoring point of the guide rail can be obtained from the curve diagram chart; the data are analyzed, calculated and outputted by microprocessor 6.

10   *Embodiment 2:*

The perpendicularity of the side and top working surfaces can be simultaneously detected by the detector of this embodiment. FIG.3 illustrates the structure of the detector.

15

Based on the above description about the operation of embodiment 1 shown in FIG.1, additional detector heads 14 and 15 are used to detect perpendicularity of top working surface of the guide rail and are installed on the upper and lower parts of instrument frame 12 respectively, outside detector heads 1 and 8. Detector heads 14

20   and 15 has the structure of a slide block type.

During the operation, the sliding surfaces of detector heads 14 and 15 contact with the top working surface, the detection method of perpendicularity of the top working surface of the guide rail is the same as that of perpendicularity of the side working

25   surface of the guide rail.

In embodiment 2, magnets 16 and 17 are installed on detector heads 14 and 15 respectively to press the sliding surfaces of detector heads 14 and 15 so that they contact tightly with the working surface of the guide rail due to the magnetic attractive

30   force between magnets 16 and17 and the guide rail.

In both embodiments 1 and 2, displacement sensor 4 is a rotary encoder that is connected with the roller of detector head 1 by flexible coupling 2. Utilizing this mechanical structure of "roller-rotary encoder", during measuring, rotary encoder is used to detect the rolling directions and rotary values of the roller along the surface of

5   the guide rail and output the electrical pulse code for counting. The rollers contact directly with the guide rail in this way of measuring. Generally, the measuring process is satisfactory. But if lubrication oil coated on the surface of the guide rail causes rollers not to roll due to decreasing in friction, the measuring accuracy may suffer.

10   For this reason, in another embodiment of the invention, the rotary encoder type displacement sensor 4 is replaced with the photoelectric displacement sensor, which does not come in contact with the working surface of the guide rail, thus avoiding the limitation and effect caused by the conditions on the guide rail. This type sensor works like the optical mouse used with the computer. The gap between the photoelectric

15   displacement sensor and the surface of the guide rail is above 1 mm.

The present invention compared with the existing technologies has the following advantages:

20   1.   Picking up automatically the measured data by sensor, and analyzing and outputting measured data by a microprocessor to achieve automation of the detecting process, reduce operator's labor intensity, and reduce the time of the detecting process.

25   2.   Improving significantly the measuring accuracy, avoiding the effect of operator's personal variations on measuring accuracy.

3.   Capable of general purpose applications in measuring guide rails, suitable not only in detecting perpendicularity of lift guide rails, but also in detecting horizontality of

30   guide rails for other heavy mechanical equipment, such as rails of the railway and guide rails for moving cranes, etc.

The foregoing description can be read in conjunction with the specific embodiments and accompanying drawings, is only exemplary of the principles of the present invention and should not be viewed as limitations to the present invention. Thus, the apparatus for practicing the detection method of the invention is not limited in anyway to the described embodiments. Any equivalent variations or modifications to the structure of the described method and apparatus or its relevant application methods are within the scope of the claimed protection.